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VENUS: A SUMMARY OF PRESENT KNOWLEDGE

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TABLES

I. ORBIT

Venus is the second known planet from the sun. Its orbit is almost exactly circular and carries it between Mercury and Earth. A comparison of the orbital elements of Venus with those of Earth is given in Table 1. This data is derived from the U.S. Naval Observatory Ephemeris for 1962[1] and from Allen[2].

From the estimated planetary coordinates of Porter _et_ _al_.[3], inferior conjunctions of Venus for the next 20 years can be predicted (Table 2).

Due to the inclination of the orbit of Venus to the ecliptic, inferior conjunctions rarely appear as transits of the sun. The only transits between the years 1600 and 2200 are given in Table 3.

Occultations of other planets by Venus have been observed, but are rare[4]. Occultations of stars by Venus are more common[5,6,7,8] and have been used to estimate the extent of the planet's atmosphere.

Table 1. Orbital Elements

	Venus	Earth
Mean distance from sun (A.U.*)	0·723,332	1·000,000,2
Inclination of orbit to ecliptic	3^{o}·394,26	defines the ecliptic
Longitude of ascending node	76^{o}·345,97	--
Longitude of perihelion	131^{o}·049,34	102^{o}.286,39
Eccentricity of orbit	0·006,791	0.016,724
Mean daily motion	1^{o}·602,130	0^{o}·985,609
Solar distance at perihelion (A.U.*)	0·718,384	0·983,276
Mean orbital velocity (km/sec)	35·05	29·8
Sidereal period (days)	224·701	365·26
Synodic period (days)	583·92	--
Longitude 1962 December 2·0	80^{o}·797,861	--

*The generally accepted value for the astronomical unit is 149,525,000 ± 10,000 km.

Table 2. Inferior Conjunctions of Venus to 1980

	Date	Approx. longitude
1.	1964 Jun. 20	$270^{\circ}.0$
2.	1966 Jan. 26	$155^{\circ}.2$
3.	1967 Aug. 30	$336^{\circ}.0$
4.	1969 Apr. 9	$199^{\circ}.5$
5.	1970 Nov. 10	$47^{\circ}.4$
6.	1972 Jun. 18	$268^{\circ}.4$
7.	1974 Jan. 24	$153^{\circ}.0$
8.	1975 Aug. 28	$333^{\circ}.2$
9.	1977 Apr. 7	$195^{\circ}.8$
10.	1978 Nov. 8	$44^{\circ}.9$
11.	1980 Jun. 15	$86^{\circ}.2$

Table 3. Transits of Venus

1.	1631	Dec. 6
2.	1639	Dec. 4
3.	1761	Jun. 5
4.	1769	Jun. 3
5.	1874	Dec. 8
6.	1882	Dec. 6
7.	2004	Jun. 7
8.	2012	Jun. 5
9.	2117	Dec. 10
10.	2125	Dec. 8

II. DIMENSIONS AND MASS

As the clouds of Venus are impenetrable and never clear, all estimates of the diameter of Venus are not of the solid planet, but of the planet + atmosphere. There are two sources of inaccuracy in determinations of diameter[9]. The first is errors in the measurement of angular diameter. Thus an error of ± 0.01 seconds of an arc is equivalent to an error of ± 14 km in the calculated linear diameter, while an inaccuracy of ± 10,000 km in the assumed separation of Earth and Venus is equivalent to an error of ± 1 km in the diameter. Now ± 0.01 seconds of an arc is approximately the predicted micrometer error in measuring Venus. The error in separation estimates depends upon the relative positions of the planets in their orbits. Thus the maximum separation is 1·723332 A.U. and the minimum 0·276668 A.U. The generally accepted error in knowledge of A.U. is ± 10,000 km. Hence at maximum separation the error due to this factor in the calculated diameter of Venus is about 2 km, and at minimum separation, less than 1 km.

Analysis of the calculated linear diameters of Venus by different workers has been presented by Makemson, *et al.*[10] and a summary of their results is given in Table 4.

All attempts to detect polar flattening of Venus have been unsuccessful[11] and the oblateness (equatorial radius - polar radius) ÷ (equatorial radius) = 0.00.

Taking the linear diameter of Venus to be 12,200 km this gives a volume of $9{\cdot}55 \times 10^{20}$ $m.^3$ and a surface area of $4{\cdot}68 \times 10^{14}$ $m.^2$

Due to the absence of a natural satellite, the mass of Venus has to be calculated from observations of planetary motions. The result is normally expressed as a fraction of the solar mass. Results of mass determinations of Venus over the past century have been reviewed by Makemson _et al._[10] and a summary of their results is given in Table 5.

Taking the mass of the sun as $1{\cdot}991 \times 10^{33}$ g., this gives an absolute mass for Venus, using the figure of Makemson _et al._[10], of $4{\cdot}892 \times 10^{27}$ g. (Earth = $5{\cdot}983 \times 10^{27}$). Combining this figure with that for volume given above, the mean specific gravity of the planet is 5·15 (Earth = 5·52).

The acceleration due to gravity at the visible surface can be calculated from the diameter and mass. Taking the diameter as 12,200 ± 40 km, the mass as 1/407,100 ± 1000 solar masses, the acceleration due to gravity (g) becomes 877 ± 8 cm/sec^{-2}. Taking the distance between the top of the white clouds of Venus and the solid surface as 50 km, the solid surface g will be approximately 890 cm/sec^{-2} (Earth surface g = 981 cm/sec^{-2}).

Table 4. Linear Diameter

Diameter (km)	Author and Year
1. 12,640	Rabe (1928)[12]
2. 12,513	Ross (1928)[13]
3. 12,060	Muller (1948)[14]
4. 12,246	Kuiper (1952)[15]
5. 12,400	Allen (1955)[2]
6. 12,200	Menzel and de Vaucouleurs (1960)[8]
7. 12,200	Martynov (1960)[16]
8. 12,200	Makemson, *et al*. (1961)[10]

range 12060 to 12,640 km

mean 12,294 km

Earth linear diameter = 12,742 km (mean)

Table 5. Mass of Venus

	Solar masses	Author and Year
1.	1/408,000	Newcomb (1895)[17]
2.	1/403,490	Ross (1916)[18]
3.	1/406,358	Fotheringham (1926)[19]
4.	1/404,700	Jones (1928)[28]
5.	1/404,000	DeSitter and Brouwer (1938)[21]
6.	1/407,000	Morgan and Scott (1939)[22]
7.	1/409,300	Clemence (1943)[23]
8.	1/406,644	Rabe (1949)[24]
9.	1/409,600	Kuiper (1952)[15]
10.	1/408,600	Allen (1955)[2]
11.	1/407,000	Makemson, _et al_. (1961)[10]

range 1/403,490 to 1/409,600

mean 1/406,608

Earth mass = 1/332,700

III. APPEARANCE, ALBEDO AND COLOR

In the telescope, Venus presents a series of phase changes similar to those of the Moon. At its closest approach, only a narrow crescent can be seen, while at its greatest distance, the planet shows a full disk.

The visual albedo of Venus has been reported at values ranging between 0.59 and 0.76. (de Vaucouleurs[25]). It is probable, however, that the albedo is a function of wavelength, and few specific measurements have been reported, though Kuiper[15] records an albedo of 0.76 for 5500 Å (a wavelength corresponding to the peak of solar radiant energy).

Color measurements of Venus have been made at several observatories and results are shown in Table 6 (Harris[26]).

In the telescope, Venus appears as a bright image tinged with yellow. Attempts to actually measure the color of Venus in terms of the "color index" (difference in magnitude at 4250 Å) have been not very successful and results ranging from 0.6 to 1.2 have been reported (Evans[9]). This should be contrasted with the color index of G-class stars, such as the sun, which vary from about 0.57 to 0.65.

Table 6. Color of Venus

	Mean color		Difference between planet and sun		
	U-B	B-V	U	B	V
Venus	0.50	0.82	0.55	0.19	0.00
Mars	0.58	1.36	1.17	0.71	0.00
Jupiter	0.48	0.83	0.54	0.20	0.00
Sun	0.14	0.63	--	--	--

U ultraviolet (~ 3700 Å)

B blue (~ 4250 Å)

V visible (~ 5280 Å)

IV. ATMOSPHERE

The atmosphere of Venus is dense and contains large particles of some material with high reflecting power. Several attempts have been made to determine the depth of the atmosphere. Perhaps the most reliable are measurements made during occultations of stars by Venus. The results of these studies are given in Table 7 and indicate an atmospheric depth of 90 to 120 km. For comparative purposes: the highest clouds in the Earth's atmosphere are at an altitude of about 85 km.

The composition of the atmosphere of Venus is still obscure, and the only gas identified satisfactorily is CO_2. Table 8 lists the major identified absorptions in the spectrum of Venus (after Rea[27]).

It will be seen that the evidence for the presence of CO_2 is excellent, but the evidence for other components is quite meager.

The identification of CO presumably implies the photo dissociation of the dioxide in the upper atmosphere. As another product of this reaction is oxygen, traces of the latter gas may occur above the clouds and account for the recently reported detection of oxygen by Prokofiev[28].

The estimated amount of each gas above the cloud layer is as follows:

CO_2 c.1000 meter-atmospheres (Herzberg[29])

CO c.23 cm - atmospheres (Sinton[30])

H_2O c.$1.9 \pm 1.6 \times 10^{-3}$ g/cm^2 (Strong, *et al.*[104])

It should be emphasised that these values estimate the amounts of each gas above the cloud layer. There is no data on the composition of the atmosphere below the clouds, though it is clear that CO_2 is a major constituent.

Other components that might be expected are argon and nitrogen. The first of these is impossible to detect spectrographically on Earth. Emission lines in the Venusian spectrum have been ascribed to N_2^+ by Kozyrev[32] and by Newkirk[33].

However, these results were not confirmed in a later study by Weinbert and Newkirk[34].

Examinations of the spectra of Venus in other regions is still in the experimental stage, and few results are available. Sinton[30] has recorded spectra from 1.1 to 4.0 μ . Absorptions were seen with band centers at 1.1, 1.2, 1.45, 1.55, 1.7, 2.05, 2.25, 2.51, 3.08, 3.15, and 3.28 μ . Sinton and Strong[31] have recorded the spectra from 8 to 13 and found only a weak absorption band at 11.2 μ . Rea[27] has suggested this feature to be due to inorganic carbonates, while Sinton[105] has suggested polymerized C_3O_2.

Upper limits can be placed on the presence of some other gases from the work of Kuiper[15] on spectra in the 1.5 to 2.2 μ range.

Only trace amounts of N_2O, CH_4, C_2H_4, C_2H_6, or NH_3 could be present.

Kozyrev[106] has reported the presence of emission lines due to formaldehyde, but this has not been confirmed by other workers, while Wildt[107] placed an upper limit of 0.3 cm atmos. on formaldehyde from the lack of absorption at 3550 Å.

Heyden, et al.[35], have ascribed a broad continuum in the near-ultraviolet spectrum of Venus to N_2O_4. The identification, however, should be regarded as only tentative due to the very low amounts of O_2 and N_2O (both photo dissociation products of N_2O_4).

Present views on the chemical composition of the gases of the atmosphere of Venus are summarized in Table 9. It will be seen that the total available information is very limited.

Largely, because of this lack of chemical information on the gases of the atmosphere, little is known of the clouds. There is reason to believe that there are two layers of clouds on the planet (Sagan[36]). The top of the dense white (or yellow-white) clouds is approximately 30 or 40 km above the surface, while a second thinner layer of dark, ultraviolet-reflecting clouds occurs about 100 km up.

Polarization studies of the clouds have been conducted by Lyot[37] and by Dollfus[38]. Both conclude that the polarization data can be interpreted as due to fine droplets c.2 μ in diameter forming the upper region of the white clouds. Water droplets of this size would be compatible with the experimental data, but so would very small transparent crystals.

Numerous hypotheses have been proposed for the chemical composition of the clouds of Venus. As the available data is so meager, these are merely summarized in Table 10. At the present time no hypothesis satisfactorily accounts for the properties of the clouds, and it is likely that they are mixtures of several types of substances.

Attempts to measure atmospheric movements and circulation have been made by several workers. Mintz[39] has suggested the presence of two distinct types of movement. The first is a high-level linear circulation in the upper atmosphere; the second a radial low-level circulation emanating from the sub-solar point.

However, Moore[40] has claimed that the observed radial markings of Venus, on which the second pattern is based, are illusory and due to optical effects in the telescope.

Ultra-violet photography (Ross[14]) has also been used to study atmospheric movements, and the presence of time-variable light and dark areas, sometimes stretching in bands, has been clearly demonstrated. Variations in polarization across the disk have been studied by Dollfus[38], who found regions of high negative polarizations near the supposed poles. The outlines of these regions changed continuously and rapidly.

There is no doubt that the atmospheric circulation of Venus is a complex phenomenon and difficult to study from Earth.

Table 7. Depth of Atmosphere from Occultation Studies

Star Occulted	Depth of atmosphere (km)	Author
Eta Geminorum	80 to 110	Antoniadi *et al.*[5]
36 Arietis	120	Haas[7]
Regulus	95	Menzel and de Vaucouleurs[8]

Table 8. Identified Spectral Features of Venus

Band center (wavelength in microns)	Author	Molecule
0.7158	Spinrad[41] Hertzberg, *et al*.[42]	$C^{12}O_2$
0.7828	Adams, *el al*.[43] Spinrad[41]	$C^{12}O_2$
0.7891	Adams, *et al*.[43] Herzberg[42]	$C^{12}O_2$
0.8698	Adel, *et al*.[44] Chamberlain, *et al*.[45]	$C^{12}O_2$
1.038	Kuiper[15] Chamberlain, *et al*.[45]	$C^{12}O_2$
1.051	Kuiper[15] Chamberlain, *et al*.[45]	$C^{12}O_2$
1.065	Kuiper[15] Chamberlain, *et al*.[45]	$C^{12}O_2$
1.206	Kuiper[15] Gebbie, *et al*.[46]	$C^{12}O_2$
1.221	Kuiper[15]	$C^{12}O_2$
1.293	Kuiper[15] Gebbie, *et al*.[46]	$C^{12}O_2$
1.317	Kuiper[15] Sinton[30]	$C^{12}O_2$
1.434	Kuiper[15] Gebbie, *et al*.[46] Sinton[30]	$C^{12}O_2$
1.50	Kuiper[15] Sinton[30]	$C^{12}O_2$

1.538	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
1.575	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
1.606	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
1.646	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
1.961	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
2.009	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
2.060	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{12}O_2$
1.475	Kuiper[47] Gebbie, et al.[46] Sinton[30]	$C^{13}O_2$
2.347	Sinton[30]	CO
1.13	Strong, et al.[104]	H_2O

Table 9. Gases in the Atmosphere of Venus

	Gas	Amount	Comments
1.	CO_2	>1000 m atmos.	amount below clouds unknown.
2.	CO	c. 23 cm atmos	photo dissociation product of CO_2.
3.	H_2O	c. $1.9 \pm 1.6 \times 10^{-3}$ g/cm^{-3}	experimental error in detection makes the value dubious.
4.	N_2	not known	identification based on spectra that have not been repeated.
5.	O_2	<80 m atmos.	if present, probably a photo dissociation product
6.	H_2CO	<0.3 cm atmos.	identification doubtful
7.	N_2O	<100 cm atmos.	---
8.	CH_4	<20 cm atmos.	---
9.	C_2H_4	<3 cm atmos.	---
10.	C_2H_6	<1 cm atmos.	---
11.	NH_3	<4 cm atmos.	---
12.	H_2	<12 km atmos.	probably not present.
13.	A^{40}	similar to terrestrial atmos.	produced from K^{40} in surface rocks.
14.	N_2O_4	not known	identification doubtful.

Table 10. Clouds of Venus

Suggested composition	Author & year	Comments
1. formaldehyde polymers	Wildt (1937)[107]	absorptions due to H_2CO are undetectable in the spectrum
2. polymerized C_3O_2	Kuiper (1957)[48]	absorption at 11.2 could be this material: however the polymers are brown and very unstable
3. droplets of water or ice	Menzel and Whipple (1955)[49]	amounts of H_2O detected are very low; the color index of Venus is significantly lower than water clouds
4. hydrocarbons	Hoyle (1955)[50] Mintz (1961)[39]	terrestrial hydrocarbons are widely assumed to be biological in origin
5. quartz + iron oxides	Kuiper (1952)[15]	geochemical production unlikely
6. ammonium nitrate	Dauvillier (1958)[51]	reflectivity too low
7. nitrogen tetroxide	Heyden, *et al.* (1959)[35]	reflectivity too low
8. $CaCO_3 + MgCO_3$	Öpik (1961)[52]	geochemical production unlikely
9. volatile organic compounds	Briggs (1959)[53]	unlikely to co-exist with CO_2
10. discharge polymers	Wilson (1960)[54]	reflectivity too low

V. TEMPERATURE

There have been numerous estimates of the temperature of Venus based on analyses of the radiation received at various wavelengths. As there is no certain knowledge at present where on Venus a particular class of radiation arises, interpretation of the results is difficult. Table 11 lists the details of the various temperature estimates.

It has been suggested that the microwave emission arises from an ionosphere on Venus, but the evidence makes this improbable (Sagan[36]). It seems more reasonable that a strong "green house effect" exists and that the solid surface is at around 600°K, while the upper atmosphere is about 250°K.

Table 11. Temperature Estimates

Estimate ^{o}K	Wavelength	Method	Author and year
1. 234 ± 10	8 to 13 μ	thermocouple	Petit and Nicholson (1955)[55] Sinton and Strong (1960)[31]
2. 285 ± 9	0.8 μ	CO_2 bands	Chamberlain and Kuiper (1956)[56]
3. 315 ± 70	0.80 cm	black body	Kuzmin and Salomonovich (1960)[57]
4. 410 ± 160	0.86 cm	black body	Gibson and McEwan (1959)[58]
5. 595 ± 55	3.15 cm	black body	Mayer, et al. (1958)[59]
6. 575 ± 58	3.37	black body	Alsop, et al. (1958, 1959)[60,61]
7. 575 ± 60	3.4	black body	Mayer, et al. (1960)[62]
8. 585	3.75	black body	Drake (quoted by Mayer, 1961)[63]
9. 580 ± 160	9.4	black body	Mayer, et al. (1958)[59]
10. 600 ± 65	10.0	black body	Mayer, et al. (1960)[62]

VI. ROTATION AND INCLINATION

Due to the dense cloud layers, there are no obvious permanent markings on Venus. Moreover the planet shows no oblateness. Consequently the two most difficult properties to determine are the period of rotation and the inclination of the axis.

All attempts to detect a Doppler shift due to rotation by comparing spectra of opposite limbs have been unsuccessful. This implies a rotation period of several days, but no precise minimum can be set due to the absence of knowledge on the axis inclination.

Several estimates of the period of rotation have been made from visual and photographic observations of the cloud markings. However, differences of opinion in the interpretation of the observations has led to a wide spread of estimates. More recently radar observations have been used, but the results still show little agreement.

Table 12 lists estimates of the rotation period. A more complete list was compiled by Sandner[64].

It will be seen that estimates of the rotation period fall into 3 groups: about 24 hours, about 10 - 14 days, and 225 days. There is now fair agreement that the period cannot be as low as 24 hours, due to the lack of Doppler shift between the limbs. An argument against a 225-day period, which implies that Venus continually turns the same hemisphere to the sun, is that the temperature of the upper atmosphere of both light and dark hemispheres is the same (Strong and Sinton[65]).

Several authorities have suggested that the rotation of Venus is retrograde (Slipher[66]; St. John and Nicholson[67]; Richardson[68]).

The inclination of the axis of rotation of Venus to its orbit has been estimated by Pickering[69] at 85° from visual observations. Examinations of photographed cloud markings by Kuiper[93] produced an estimated inclination of about 32°. Similar examinations by Richardson[71] gave an estimate of about 14°. It is apparent that this property of the planet is still uncertain.

Table 12. Rotation Period

Estimated rotation period	Method	Author and year
1. 23 h. 21 m.	Visual	Cassini (1666)[72]
2. 24 d. 8 h.	Visual	Bianchini (1727)[73]
3. 23 h. 21 m.	Visual	Schröter (1791)[74]
4. 24 h.	Visual	Trouvelot (1875)[75]
5. 225 d.	Visual	Schiaparelli (1877)[76]
6. 225 d.	Visual	Perrotin (1890)[77]
7. 225 d.	Visual	Cerulli (1895)[78]
8. 225 d.	Visual	Tacchini (1895)[79]
9. 23 h. 57 m. 36.2 s.	Visual	Brenner (1895)[80]
10. 225 d.	Visual	Lowell (1896)[81]
11. 24 h.	Visual	Fournier (1899)[82]
12. 24 h. 42 m.	Spectroscopic	Bélopolsky (1900)[83]
13. 225 d.	Spectroscopic	Slipher (1903)[84]
14. 225 D.	Spectroscopic	Lowell (1909)[85]
15. 225 d.	Visual	Wilson (1916)[86]
16. 20 h.	Spectroscopic	Evershed (1919)[87]
17. 68 h.	Visual	Pickering (1921)[69]
18. 8 d.	Visual	Steavenson (1924)[88]
19. 30 d.	Photographic	Ross (1927)[18]
20. 37 d. 4 h. 48 m.	Visual	Martz (1933)[89]

21.	60 d.	Spectroscopic	Wolkow (1949)[90]
22.	22 h. 30 m.	Visual	Bartlett (1952)[91]
23.	15 d.	Visual	Roth (1953)[92]
24.	a few weeks	Photographic	Kuiper (1954)[93]
25.	22 h.	Radio emission	Kraus (1956)[94]
26.	14 d.	Spectroscopic	Richardson (1958)[68]
27.	11 d.	Radar	Recent Soviet data

VII. SURFACE

There is no reliable data on the nature of the surface of Venus. The clouds never clear and no observer has ever seen beneath them. From large numbers of drawings of the planet, Danjon[95] and Dollfus[96] have found that a regular pattern can be detected. The "permanent" markings appear to keep a constant orientation towards the sun and indicate a rotation period of 225 days. It has been suggested that these regularly observed markings are caused by permanent surface features seen with difficulty through thin gaps in the clouds. However, it is quite possible that the markings are merely due to characteristic cloud patterns caused by the slow rotation of the planet, and have no connection with surface features.

The lack of information on the chemical and physical properties of the atmosphere precludes any accurate deductions on the nature of the surface. The various theories have been reviewed by Sagan[36] and are merely summarized here:

1. a surface covered with hot wet swamps
2. a planet-wide ocean of water
3. a planet-wide ocean of hydrocarbons
4. an almost completely dry, much-eroded desert

Öpik[52] has proposed a dust model of Venus in which the grinding of dust clouds against the solid surface produces the high temperature observed by microwave studies.

VIII. INTERNAL STRUCTURE

Studies of the interior of the planets are difficult to conduct, and there is still considerable controversy over the internal structure of the Earth.

Data on the internal distribution of matter within a planet can be gained from several types of observations including:

1. the overall specific gravity
2. the oblateness and period of rotation
3. perturbations in the motion of satellites
4. seismic studies of earthquakes

For Venus, which has no satellite, no detectable oblateness, an uncertain rotation period, and cannot be investigated for earthquakes, the only possible present approach to its internal structure can be by comparison with Earth, taking into consideration the difference in specific gravity.

Earth is known to possess a high-density core, surrounded by a lower density mantle: overwhich lies the thin crust. It seems probable from the similar dimensions and specific gravity that the internal structure of Venus is similar, though the core is somewhat smaller.

Accurate information will be derived only from experiments conducted on Venus.

IX. MAGNETIC FIELD

Attempts to estimate the magnetic field of Venus have been made by Houtgast[97] who has suggested that the field of Venus should tend to divert streams of charged particles emanating from the sun. Consequently, when Venus is between Earth and the sun more of the charged particles should strike the Earth than normally. By studying records of daily magnetic disturbances for 44 inferior conjunctions of Venus, Houtgast found a marked effect and was led to suggest that the magnetic field of Venus is about 5 times greater than that of Earth.

However, the magnetometer carried on Mariner (see section X) failed to detect any magnetic field of Venus, and the actual field must be considerably less than that of Earth. This is additional evidence for a slow rotation, for Earth's magnetic field is commonly supposed to arise by a dynamo-effect on the core due to the rapid rotation.

X. MARINER EXPERIMENT[98,99,100]

On 1962 August 27, the Mariner II satellite was launched from Cape Canaveral by means of an Atlas-Agena B vehicle. In the launch position Mariner was 9 feet 11 inches high and 5 feet in diameter. In space, panels unfolded to increase the height to 11 feet 11 inches and the span to 16 feet 6 inches. The total weight was 446 pounds of which 50 pounds was scientific instruments: the remaining weight being taken up by propulsion units, electronic equipment, etc.

Six types of scientific instruments were carried on the satellite. Of these only three were directly concerned with measurements of Venus. The others (ion chamber and particle flux detector, cosmic dust detector, and solar plasma spectrophotometer) were to make measurements of interplanetary space.

The three instruments directed at Venus were a microwave radiometer, an infra-red radiometer, and a magnetometer. The microwave radiometer scanned radiation from Venus at two wavelengths, 13.5 mm and 19 mm. The first wavelength is an absorption band of water, the second is not affected by water and together they were used to determine the H_2O concentration in the upper atmosphere of Venus.

The infra-red radiometer operated at 8 to 9μ and at 10 to 10.8μ, and was designed to look at the fine structure of the clouds; in particular to search for openings. The magnetometer not only detected fields due to Venus, but also measured interplanetary magnetic fields.

Radio contact with Mariner was finally lost on 1963 January 3. On 1962 December 14, the satellite passed 21,594 miles above the sunlit side of Venus and scanned the planet for 42 minutes. The radio-data is still under analysis, but several results have been released. First, no magnetic field of Venus was detected, and no magnetically trapped radiation zones were detected above the planet.

From the orbit of the satellite, it proved possible to compute a new value of the mass of Venus. This came out at 1/408,300 ± 0.015% solar masses and should be compared with the values given in Table 5.

XI. INDIGENOUS LIFE

There is no evidence of life on Venus, and if the surface temperature proves to be 600°K, the presence of organisms with a terrestrial-type biochemistry is precluded.

Several authors have suggested that their observations indicate the presence of organisms, but in no case is the evidence satisfactory. Thus Kozyrev[101] ascribed some of the absorptions detected by him in the spectra of Venus to micro-organisms, while Tikhov[102] has suggested that there is a preferential absorption of red and yellow light by the surface of Venus that is similar to light absorption by vegetation.

Housden[103] suggested that the telescopic markings of Venus were intelligently constructed artifacts. However, these markings are largely illusory.

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